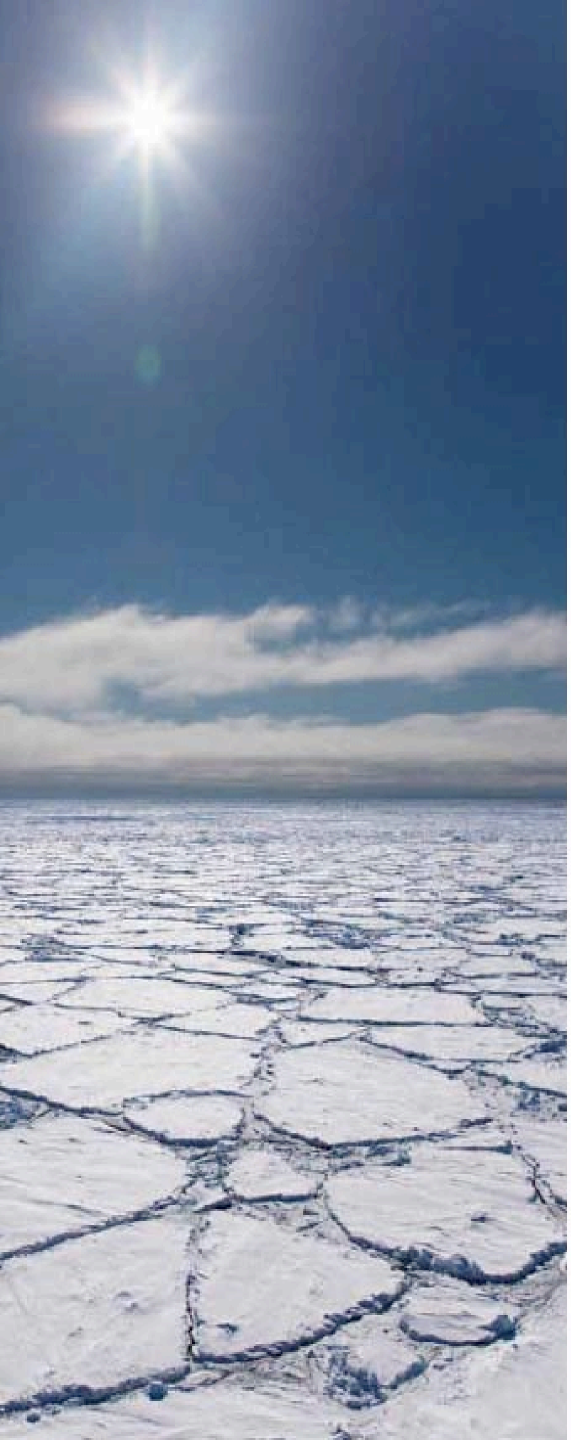


Oil in ice-covered and Arctic Waters

Challenges, developments, perceptions

Amy MacFadyen

National Oceanic and Atmospheric Administration

Office of Response and Restoration, Emergency Response Division

Emergency Response Division

- Under the National Contingency Plan, NOAA has responsibility for providing scientific support to the Federal On-Scene Coodinator (FOSC) for oil and hazardous material spills
- NOAA's Emergency Response Division provides 24-7 support for spill events
- ERD's scope encompasses the entire U.S. coastline, including the Great Lakes, Alaska, Hawaii and U.S. territories

NOAA/ERD Scientific Support for DWH Spill Response

- Modeling of oil movement – tactical trajectories for surface and subsurface oil, statistical models for “worst-case scenario”
- Overflight observations
- Biological and resource assessment
- Protection/cleanup recommendations and priorities
- Seafood safety issues
- Shoreline Assessment
- Dissemination of information – fact sheets, talking points etc.
- Data management

Sources/Acknowledgements

- John Whitney, Alaska SSC, 2010 NOAA OR&R White Paper: "ERD Arctic Team Preparedness Evaluation for a Major Oil Spill Response in the Alaskan Arctic Ocean"
- National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2010, "The Challenges of Oil Spill Response in the Arctic"
- SINTEF 2010, "Joint Industry Program on Oil Spill Contingency for Arctic and Ice-covered Waters, Summary Report"

When considering challenges and R&D needs for spill response in the Arctic there are multiple areas to consider…

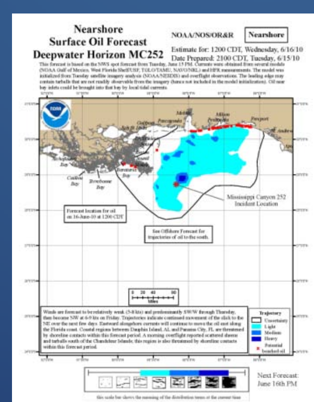
→Logistics

Alaska Clean Seas Base Camp in Deadhorse

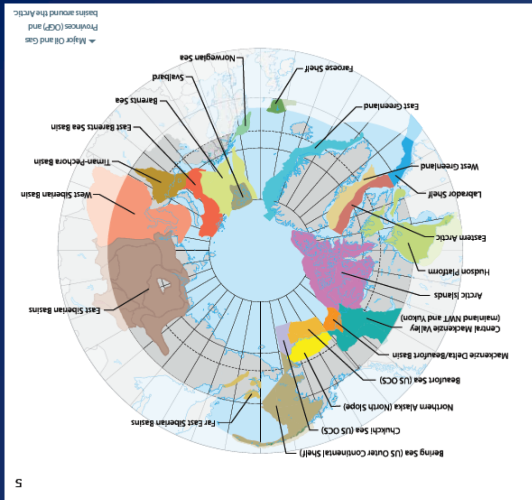
→Effectiveness of spill clean-up technologie

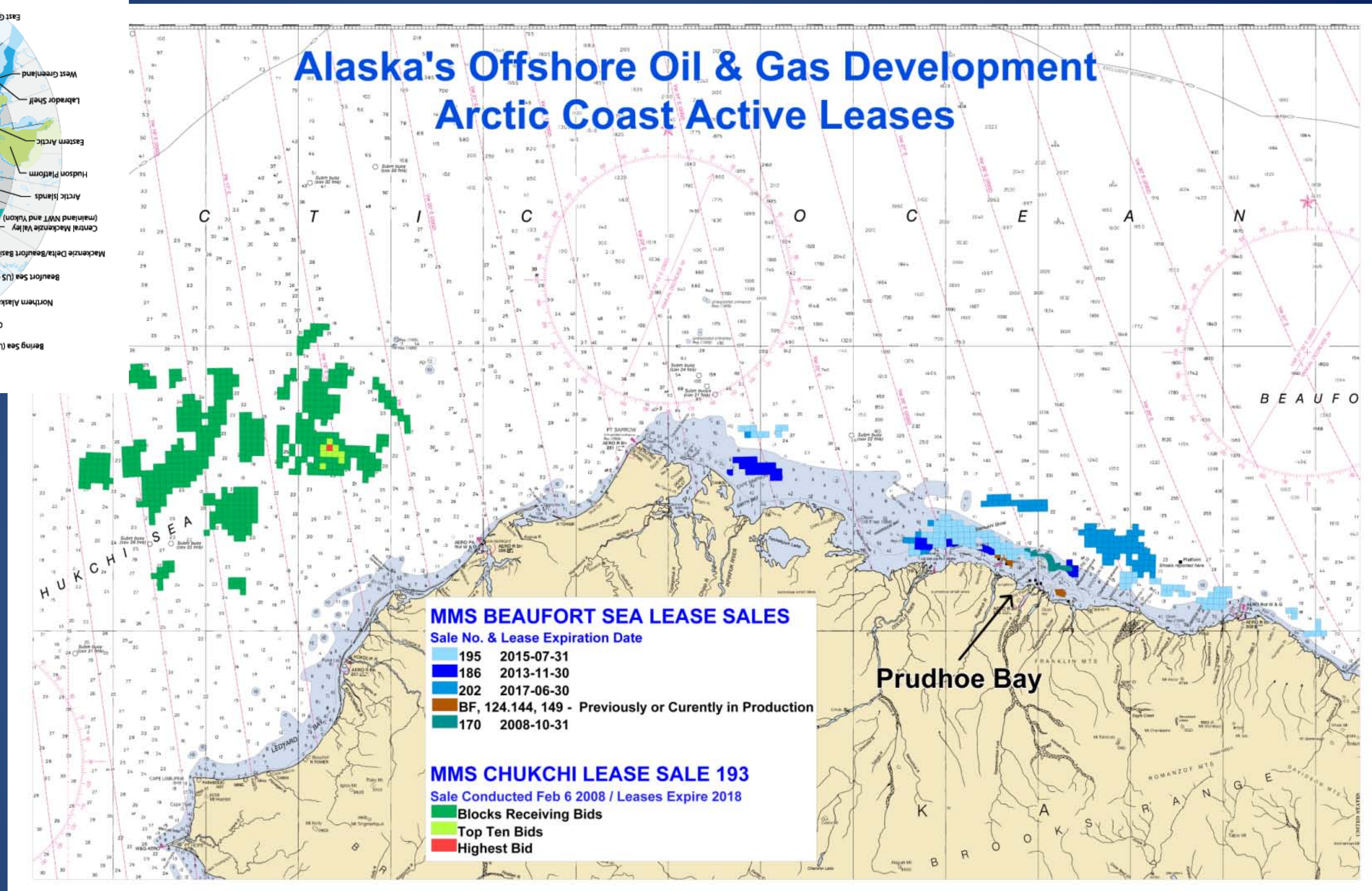
Sintef, Oil in Ice JIP 2009

→Effectiveness of Scientific Support during Response



NOAA overflight observer (left) and trajectory forecast for Deepwater Horizon (right)

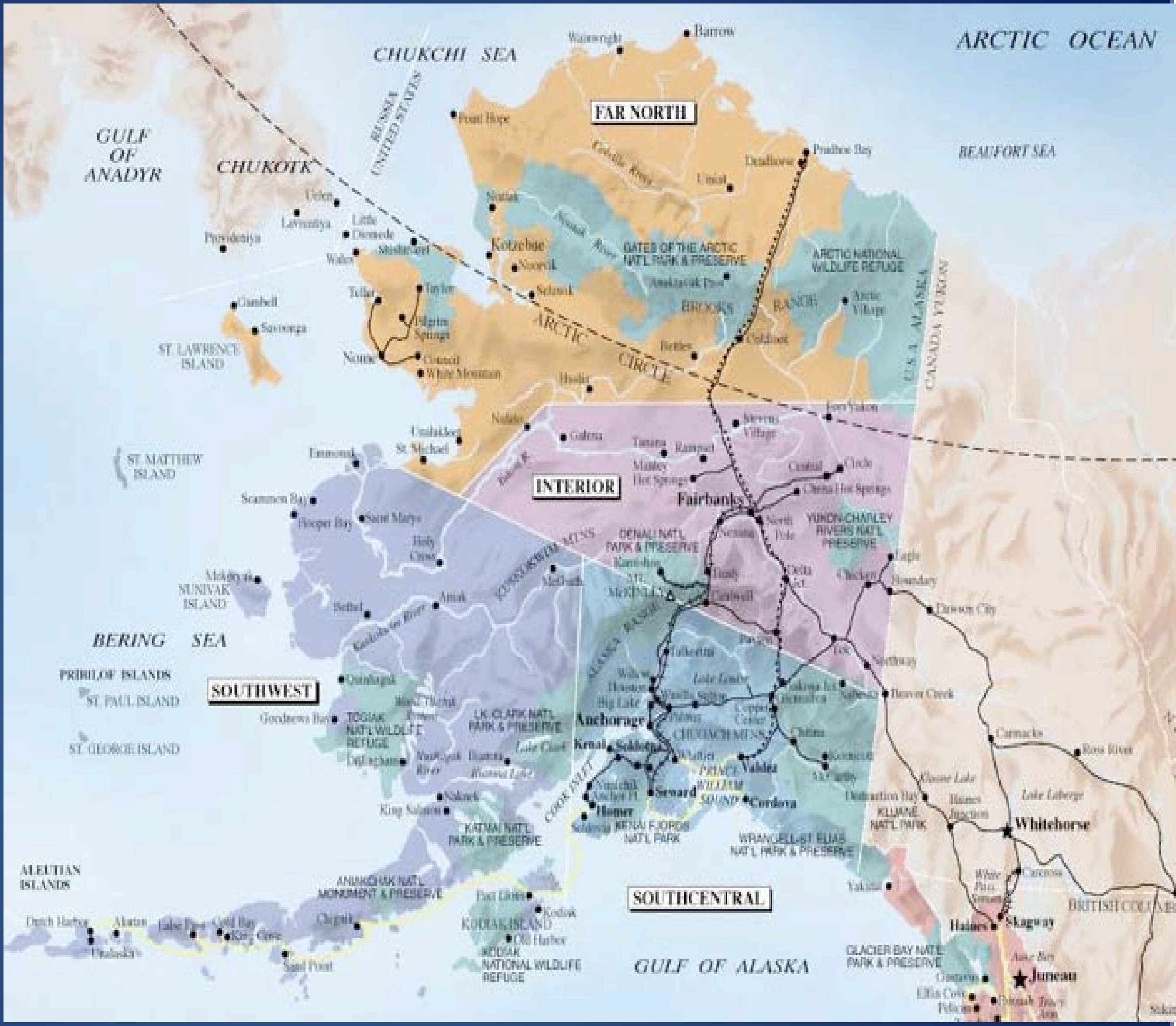




- Two locations of offshore drilling in Alaska – Beaufort Sea and Chukchi Sea
- Two sites present different drilling conditions and response issues

NORTH SLOPE SETTING (Barrow, AK):

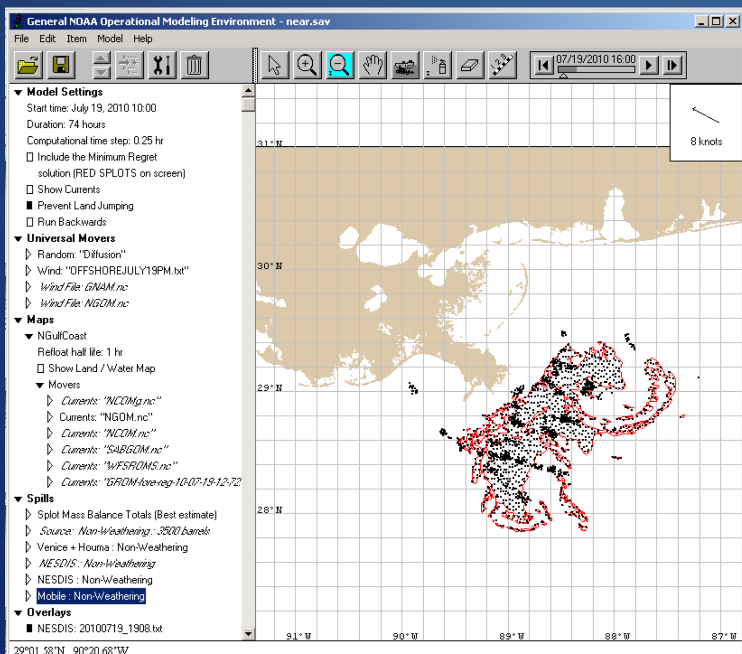
- > 2 months total darkness
- Mean Annual Temperature
  - Max = 14.4°F / -9.8°C
  - Min = 3.7°F / -15.7°C
- ~ 9 mo. total ice cover in Beaufort Sea
- Road network = 0
- North Slope dedicated CG icebreakers = 0
- North Slope large/medium vessel ports = 0
- North Slope accommodations – very limited
- Lots of hungry polar bears!!

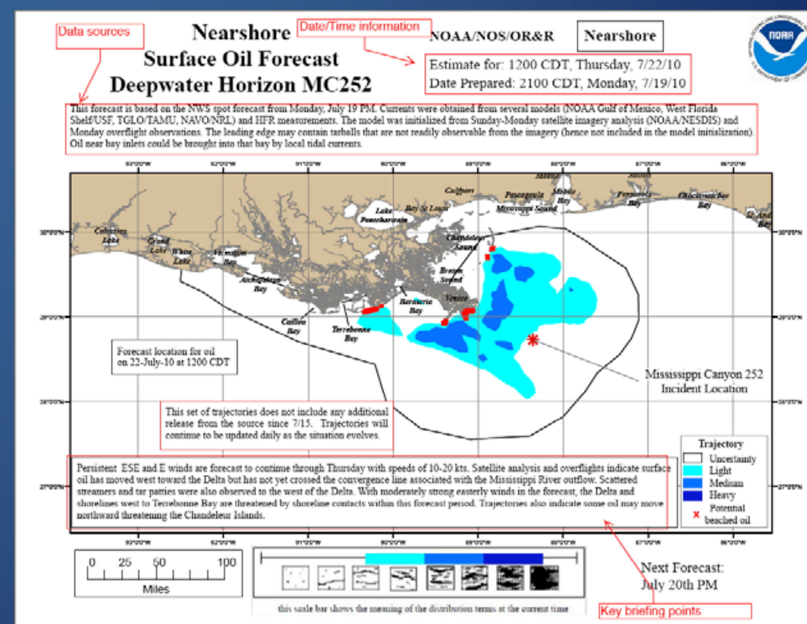


Barrow at 71.3° N. latitude, 900 statue miles from Deadhorse to CG Air Station Kodiak

Deepwater Horizon: Forecasting Oil Movement

- From April 21 through Aug 23, NOAA provided daily surface oil forecasts for 24, 48 and 72 hr periods





Oil detection and tracking

- Human observation from aerial overflight
  - Most reliable
  - Limited to clear conditions, daylight and oil may be hidden in/under ice and snow
- Synthetic Aperture Radar (SAR) Satellite
  - Not limited by darkness or clouds
  - Resolution up to 1 m
  - Spills may not be detectable in closely packed ice conditions
- Airborne Remote Sensing (SLAR, IR)
  - Expected to work best for large spills in very open drift ice
  - Spills may not be detectable in closely packed ice conditions
  - Additional operational constraints – travel distances, weather

MMS 2006 Report

<u>Oil under ice</u>

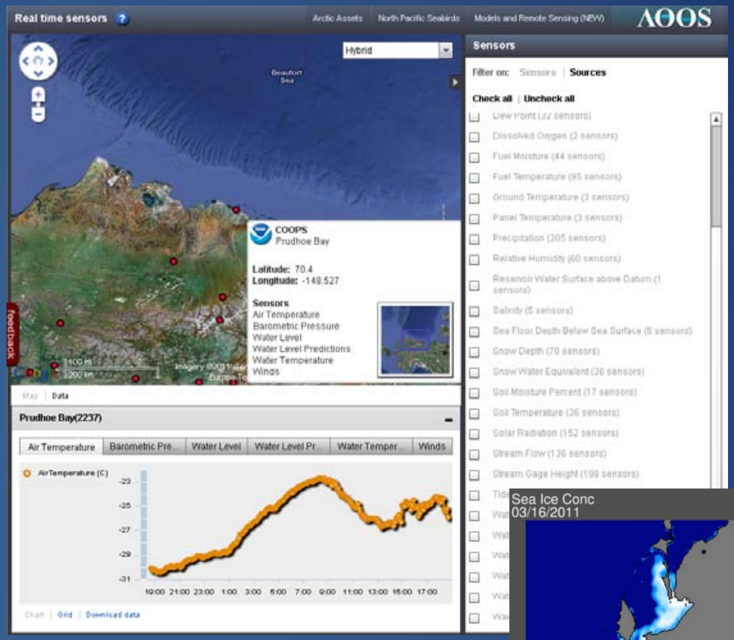
- Ground penetrating radar
  - Viewed as having most potential for detecting oil under ice
  - May not detect oil under thick, rough or rafted/ridged ice
  - JIP to develop operational helo mounted system
- Surface based systems – e.g. tracking buoys, gas sensors

SINTEF 2009 Report

Oceanographic and meteorological data

- Observational data of environmental conditions → better forecast
- In the DWH spill there was a vast amount of observational data available
  - Drifters (4 or 5 kinds)
  - HF radar data
  - Vessel based observations
  - ADCPs
  - Remote sensing
  - Met buoys
  - AUVs
- Ocean Observing Systems provide a framework to standardize data formats and provide ease of access

- **Significant lack of relevant site- and time-specific environmental data for the Arctic**
  - Satellite measurements of ice concentration
  - IABP



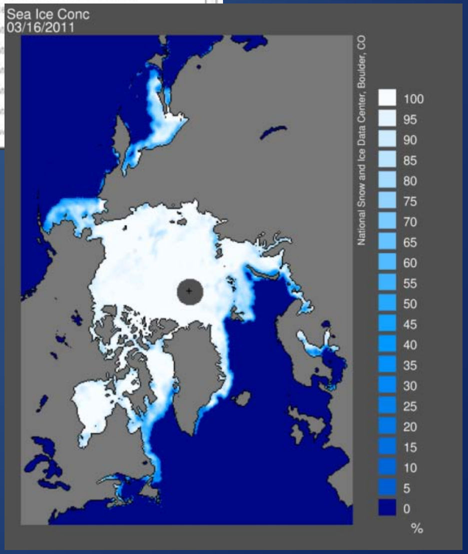


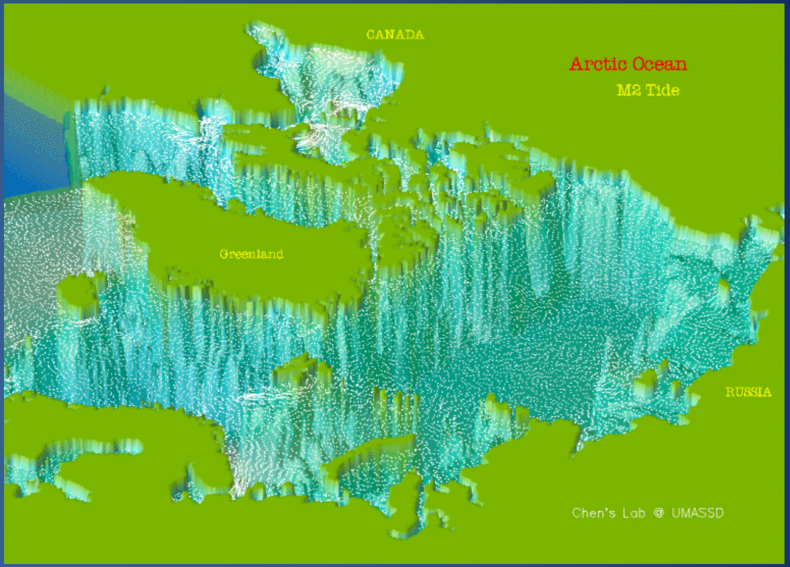
Figure 2. Polar bears inspecting a buoy from the International Arctic Buoy Program. This buoy ceased reporting temperatures shortly after this picture was taken. Photo courtesy of D.G. Barton, US Coast Guard (retired).

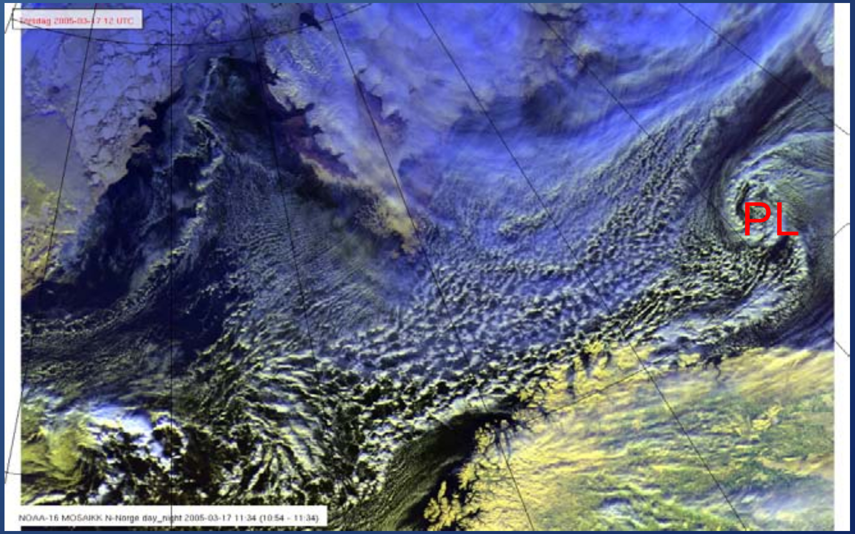
Preller et al, 2002

Wind and ocean current forecasts

- Ensemble forecast modeling contributed to successful forecasting during DWH incident – 6 hydrodynamic models, several sources for forecast winds

- Complexities of Arctic weather and ocean forecasting
  - Lack of observational data
  - Air-sea-ice interactions
  - Polar lows
  - Complex geometry of coastlines
  - Steep bottom bathymetry
  - Sea ice dynamics and thermodynamics

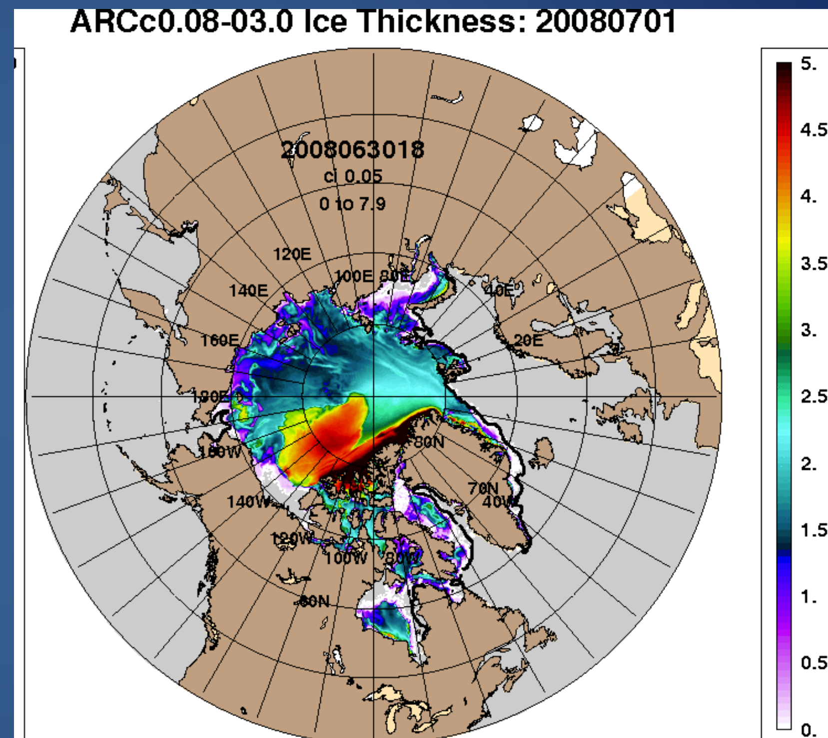




Arctic Cap Nowcast Forecast System
Naval Research Lab

- Real time ice forecasts are now available from ice centers in many countries
- Increasingly sophisticated ocean-ice-atmosphere models for the Arctic

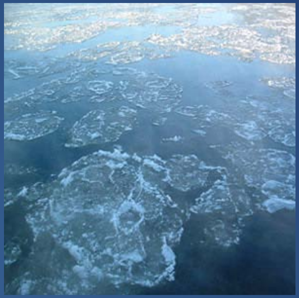
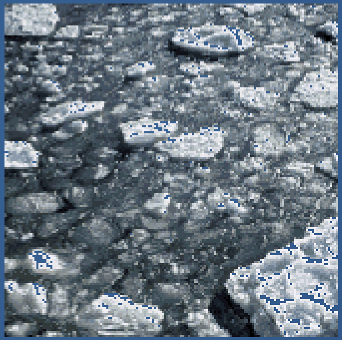
- Generally at km scale resolution



Global HYCOM ocean model + data assimilation of ocean and ice observations (NCODA) + Sea Ice model (CICE)

Behavior of Oil in Ice Conditions

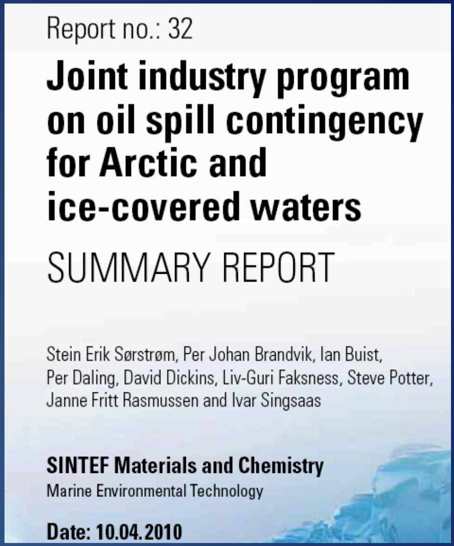
- Necessary scales to model oil-ice interactions are on the order of meters
- Complexity increased compared to similar spill in open water (i.e. many possible scenarios)
- Factors influencing behavior:
  - Nature of the ice
  - Location and distribution of spilled oil
  - Properties of the spilled oil
  - Weather and water

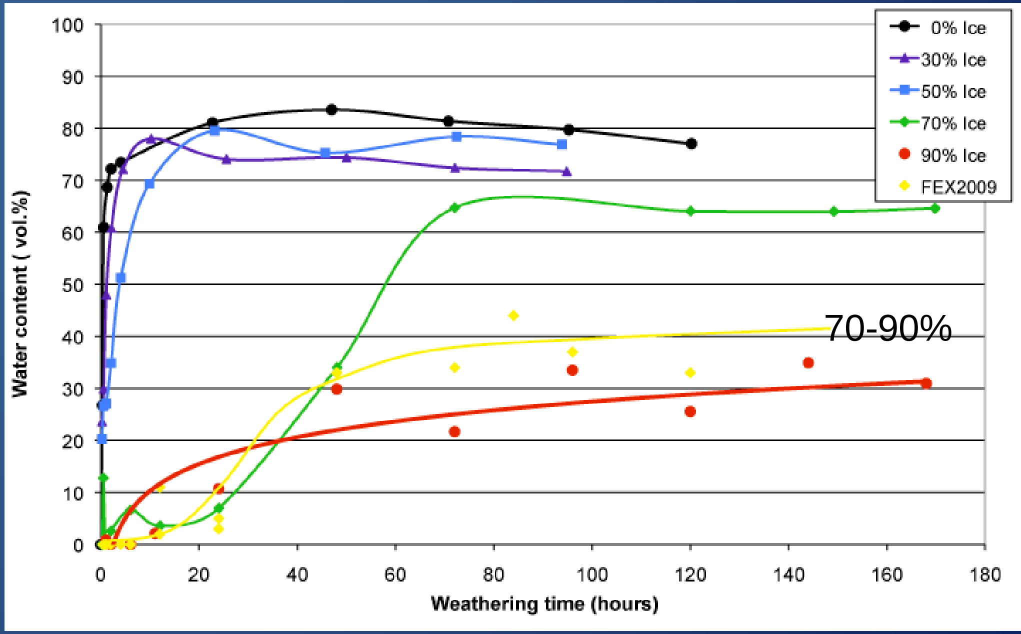




Weathering

- Existing knowledge on weathering processes in Arctic oil spills limited compared to spills in warmer or ice-free waters
- Rates of weathering processes may be reduced if ice present
  - Ice acts as natural barrier reducing spreading and dispersion resulting in thicker layer of oil
  - Evaporation slower where oil is thicker and inhibited where oil is under ice
  - Total water uptake and rate of uptake may be reduced due to dampening of wave activity

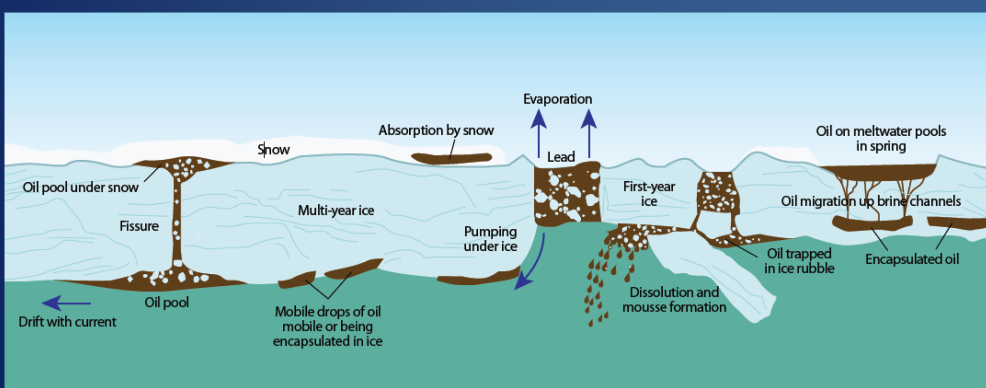
The oil spreads in between the ice floes and will follow the movement of the ice





Fate and Transport Modeling

- Prediction in specific circumstances surrounding any incident in an ice environment may be beyond ability of any one model
- Develop models for a number of possible scenarios based on
  - Ice conditions
  - Where oil is spilled
  - When



AMAP, 2007; Bobra and Fingas ,1986

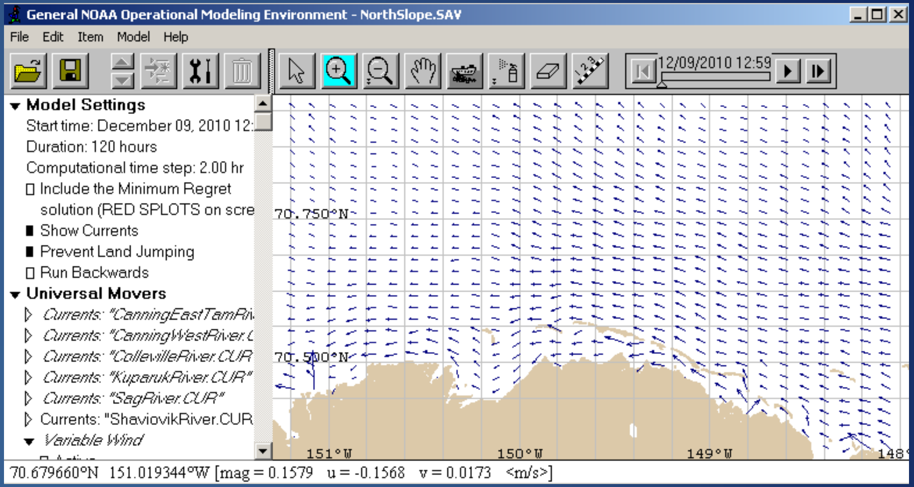
Table 2-4 Behaviour of oil spilled to different types of ice environments (NRC 2003a)

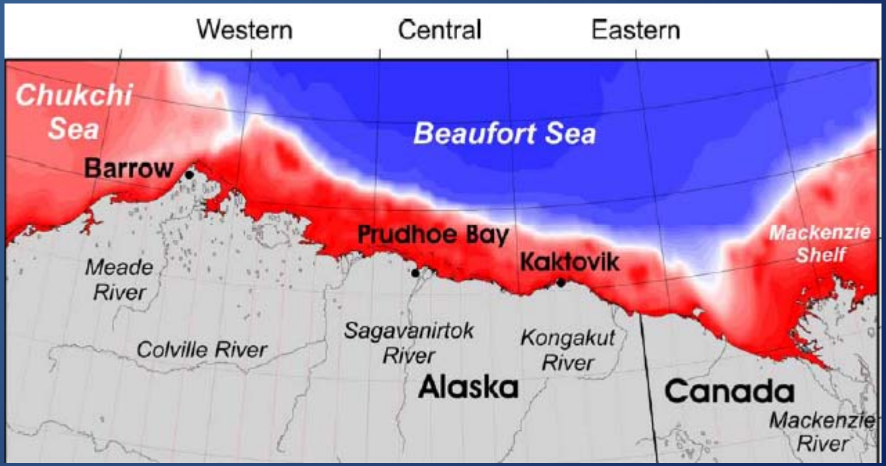
If oil is spilled…	Sub-location	Fate during freeze-up	Fate after thaw
On water	<30% ice cover	As on open water	Melt to open water
	>30% ice cover	Mostly trapped in between ice	Melt to open water
	In leads	Frozen into ice	Melt to open water
	Frazil/ grease/ brash ice	Frozen into ice	Melt to open water
Under ice	1^{st} year ice	Encapsulated	Rise via brine channels
	Multi-year ice	Encapsulated	Rise or remain in ice
Into ice		Encapsulated	Melt to open water
Onto ice	On ice	Pool & remain on surface	Melt to open water
	Under snow	Absorb into snow	Melt to open water

DeCola et al. (2006), Offshore Oil Spill Response in Dynamic Ice Conditions: A Report to WWF on Considerations for the Sakhalin II Project.

North Slope Location File

- Diagnostic coastal current pattern scaled by results from HF radar and ADCP results (Potter and Weingartner, 2006; Weingartner et al., 2009)
- Can be used for drills and planning by non-experts
- Tuned for forecasting during real incident
- Application limited to ice-free conditions (<30% coverage) → ~ 3 months of year





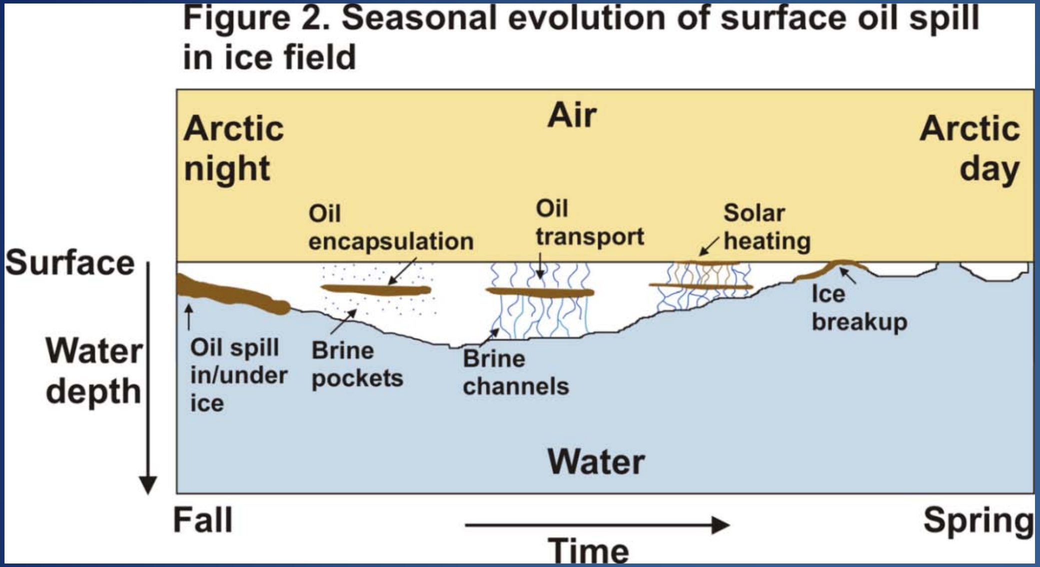
Monitor and Wait

Precedent established for M/V Kuroshima (1997/8) and for M/V Selendang Ayu (2004/5) responses in the Aleutian Islands due to extreme weather and hazardous working conditions

- May be necessitated by ice-coverage or weather
- Leave-in-place response strategy requires ability to track oil in ice (potentially over Arctic winter)
  - ACNFS vs. obs from International Arctic Buoys Program → mean 6.6 km separation over 24 hr
- Behaviour of oil in ice remains an important research topic

Biological Effects of Oil-in-Ice JIP Project

CRRC-UNH, NOAA, SINTEF, PWS-OSRI

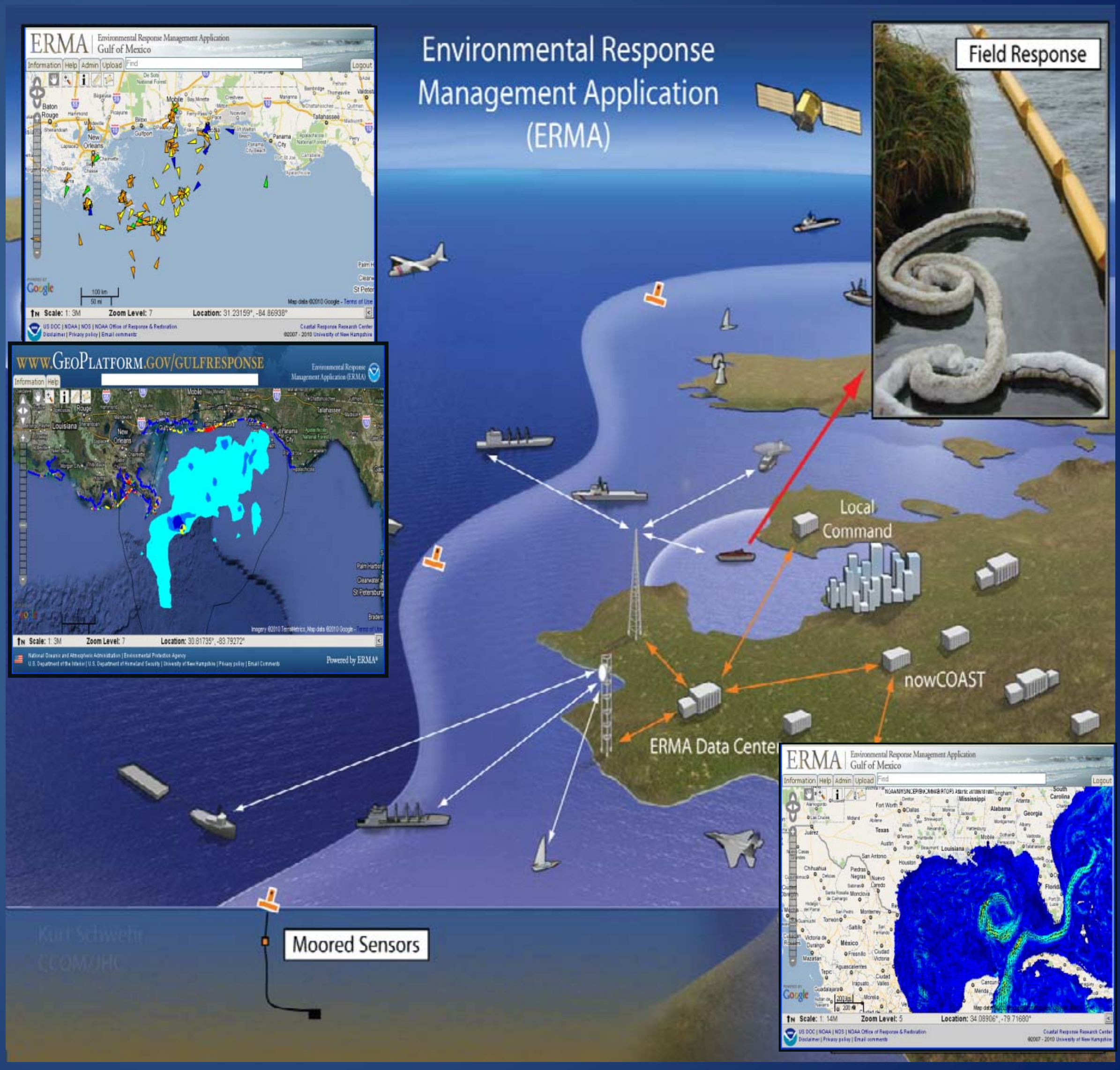


- Oil becomes encapsulated as ice forms around it
- As ice begins to melt, oil transported to surface through brine channels
- Oil is relatively "fresh" enhancing potential for in situ burning

- Most previous research focused on bulk oil movement – limited studies on dissolved components
- Determine risks of exposure to biological communities associated with ice

Arctic ERMA

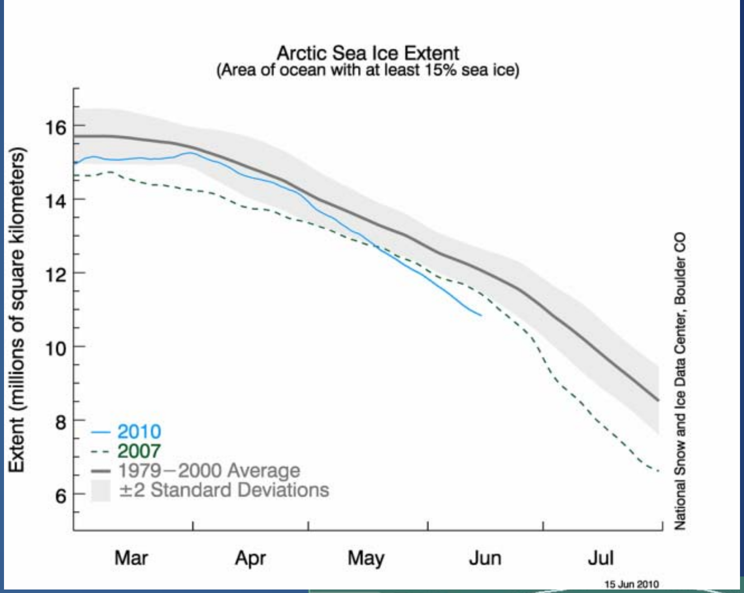
- ERMA is a geographic information tool that contains historical and real-time data
- Information can be input during a spill
- Common Operating Picture during DHW response
  - Oil trajectories
  - Weather
  - Response assets
  - Ocean observations and models
  - Response sampling
  - Field photos
  - Shoreline oiling observations

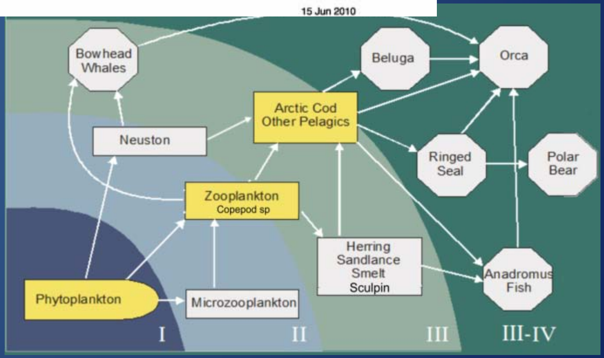


Resources at Risk in a Dynamic Environment

- In 2005 NOAA completed comprehensive Environmental Sensitivity Index (ESI) - covers coastline/near-offshore areas from Bering Strait to Canadian border
  - Biological sensitivity information
  - Human-use features
  - Shoreline types and sensitivities
- Environmental changes are occurring in the Arctic at rates much greater than projected

- These changes also create challenges for determining the baseline condition of Arctic habitats and species in the absence of a spill

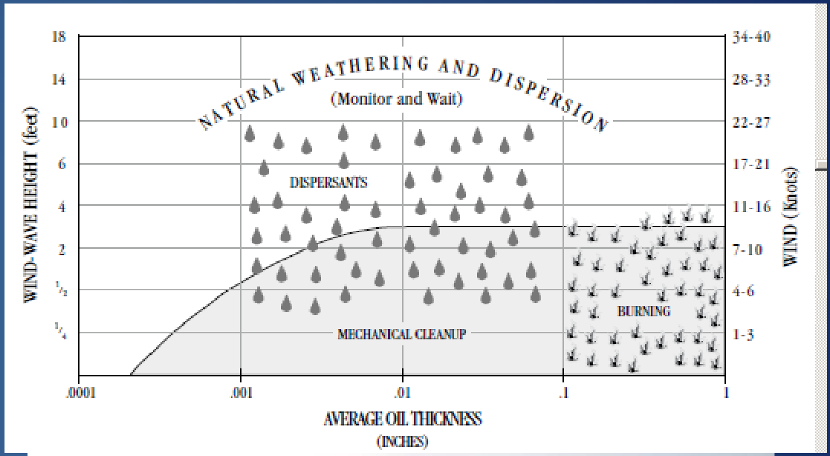




Significant gaps remain in understanding of ecologies of resources potentially at risk from oil released into Arctic waters

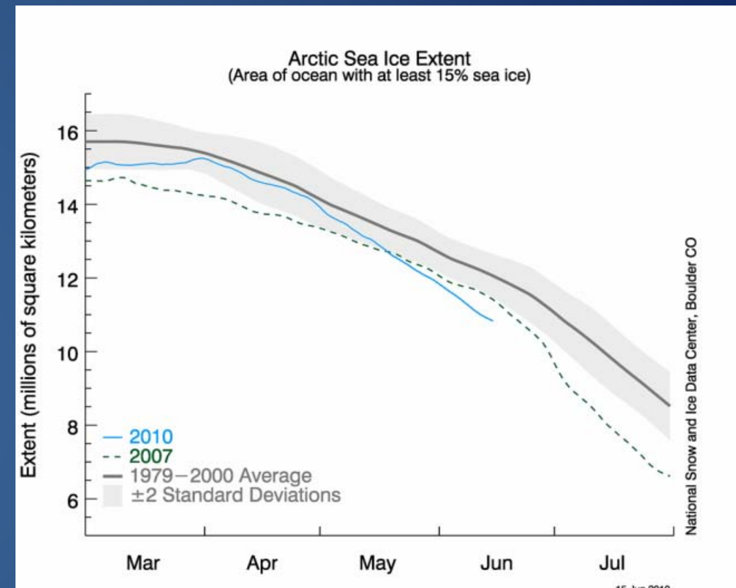
Ecological Risk Assessment (ERA) to Evaluate Arctic Response Options

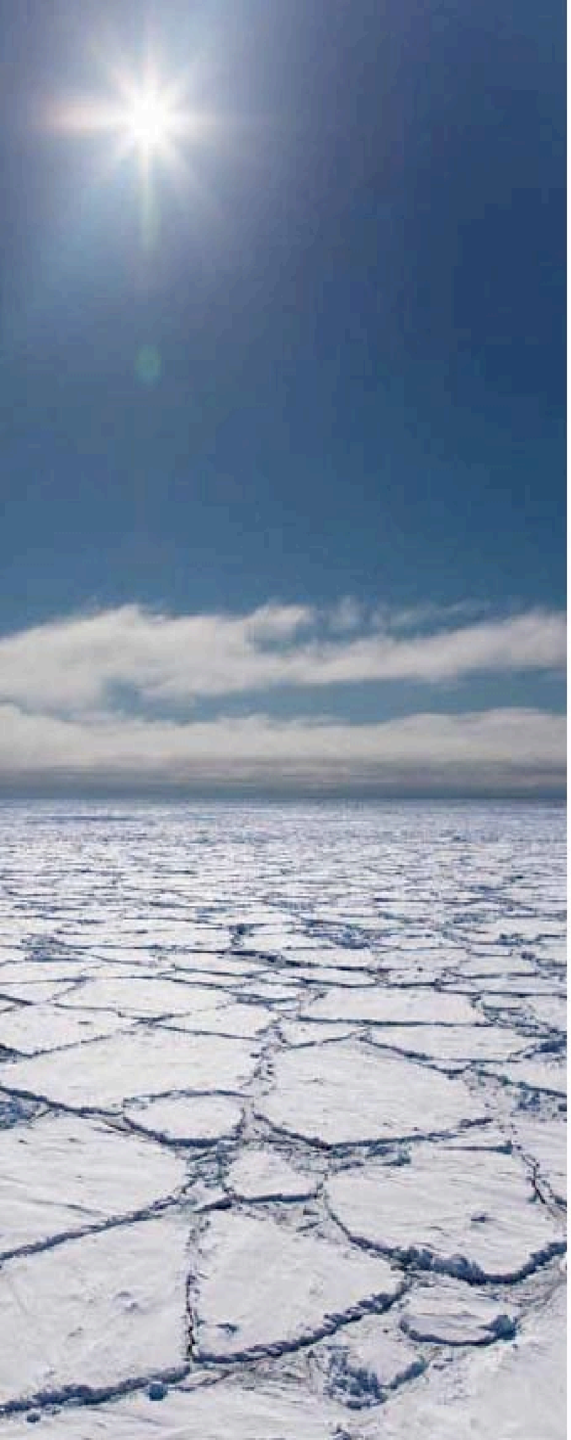
- ERA examine response options in context of specific habitats and natural resources in a specific region
- There is a need to conduct an ERA in U.S. Arctic to flush out issues unique to region
  - Dominant population in Alaska's Arctic are subsistence users of natural resources
  - Less focus on shoreline?
- Discussion, intuition-building, and consensus-building before a spill happens can facilitate a response that best enhances recovery



The future…

- Demands of energy exploration, new fishing grounds, adventure tourism, and reduced shipping distances will lead to an unavoidable increase in activity in the north and the potential for spills
- Big picture…
  - International cooperation among Arctic nations to improve joint contingency plans for international response efforts
  - Implementation of comprehensive prevention and preparedness measures (e.g. ERA’s, resources, response gap analysis)





Thank you!